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APPLICATION
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LETTERS PATENT

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FOR: APPARATUS FOR SYNTHESIZING SIGNALS DERIVED FROM AN OPTICAL DISC

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APPARATUS FOR SYNTHESIZING SIGNALS DERIVED FROM AN OPTICAL DISC

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for recording signals on an optical disc and reproducing signals from the optical disc, and more particularly to an apparatus for synthesizing signals derived from an optical disc.

2. Description of the Related Art

When an optical disc is used to record and reproduce an information signal, a beam of light is radiated on a recording layer of the optical disc and a returning beam is received by a plurality of light receiving planes (detectors) to obtain a plurality of signals. Each light receiving plane (detector) receives part of the returning beam. The part of the returning beam is referred to as a returning beam segment in this specification. The signals prepared by the light receiving planes are synthesized to create a so-called RF signal used for reproduction of the information signal, a servo signal used for focusing and tracking, or a detection signal used for detection of a pre-pit. A signal synthesizing apparatus is employed when synthesizing the signals returning from the recording layer of the optical disc.

One example of such signal synthesizing apparatus is disclosed in Japanese Patent Kokai (Laid-Open Publication) No.

2000-132835. The signal synthesizing apparatus uses a plurality of light receiving planes to capture a returning light beam. It is therefore ideal that all the light receiving planes have the same light receiving characteristics. In reality, however, it is impossible for the light receiving planes to have the same light receiving characteristics. In order to deal with this problem, the signal synthesizing apparatus of Japanese Patent Kokai No. 2000-132835 relies upon variable gain amplifiers to adjust signal levels of the returning light beam segments such that the signal levels of the returning light beam segments become equal to a predetermined reference value.

Practically, however, a plurality of light receiving elements which constitute each light receiving plane have great variation in optical and physical characteristics. In addition, the reference value mentioned above cannot be separated from the signal levels of the returning light beam segments in order to insure an appropriate functioning of the variable gain amplifiers. This imposes considerable limitations on determination (selection) of the reference value and design of a feedback circuit including the variable gain amplifiers.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a signal synthesizing apparatus for an optical disc which can be easily designed and which has a relatively simple circuit structure.

According to one aspect of the present invention, there is provided a signal synthesizing apparatus comprising: an

optical pickup having a plurality of light receiving planes (detectors) for receiving a beam returning from an optical disc when a reading beam of light is radiated to the optical disc, and for producing a plurality of signals from segments of the returning beam in accordance with, for example, optical intensities of the returning beam segments; adjusting means for adjusting signal levels of the signals such that each of the signal levels becomes equal to a reference value determined from at least one of the signal levels; and synthesizing means for synthesizing the signals after the signal levels are adjusted by the adjusting means to obtain a synthesized signal. Since the reference value is decided on the basis of the signal level(s) of the returning light beam segment(s), there is no need to separately or specially prepare a reference value. Therefore, the signal level adjustment is simplified. Further, the whole circuit structure is simplified. This contributes to a reduction of manufacturing cost of the signal synthesizing apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a block diagram of a signal synthesizing apparatus according to the present invention;

Figure 2 illustrates a block diagram of a major portion of the signal synthesizing apparatus shown in Figure 1;

Figure 3 illustrates a circuitry diagram of a level detection circuit shown in Figure 2; and

Figure 4 illustrates a circuitry diagram of a modified level detection circuit.

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DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be described in reference to the accompanying drawings.

Referring to Figure 1, illustrated is an apparatus for synthesizing a plurality of signals derived from a light returning from an optical disc according to the present invention.

A single beam of light is radiated to an optical disc (not shown) from a light source (not shown), and a returning beam from the optical disc is passed through an intermediate optical system or assembly (not shown) and received by four light receiving planes (detectors) A, B, C and D. A single light receiving unit 1 includes the four planes A to D. The returning beam includes four segments, which are respectively received by the four detectors A to D. Although not illustrated, the light source and the intermediate optical system are parts of an optical pickup which is connected with the light receiving unit 1. The position of the optical pickup is controlled relative to the optical disc by a focusing servo or tracking servo mechanism.

Signals of the returning beam segments received at the planes A to D are supplied to a level adjusting circuit 2 respectively. These signals are referred to as signals A to D respectively. The level adjusting circuit 2 appropriately adjusts the signal levels of the received beam segments and supplies the adjusted signal levels to first and second signal synthesizing circuits 3 and 4. The first signal synthesizing

circuit 3 creates a first synthesis (composite) signal having a signal level in accordance with an operation: (Signal A + Signal B) - (Signal C + Signal D). The second signal synthesizing circuit 4 creates a second synthesis signal having a signal level in accordance with an operation: (Signal A + Signal B + Signal C + Signal D).

The first synthesis signal passes through a low pass filter 5 and becomes a tracking servo signal TE. The first synthesis signal also passes through a high pass filter 6 and becomes a wobble signal WOB. The high pass filter 6 excludes a component generated from disc eccentricity included in the first synthesis signal. In the illustrated embodiment, the cutoff frequency of the high pass filter 6 is set to be as high as possible as long as it does not exert adverse affects on the 140 kHz wobble signal WOB in terms of amplitude and phase. The cutoff frequency is, for example, 14 kHz. The wobble signal WOB is introduced to a pre-pit detection circuit 9 to extract a pre-pit signal LPP. Details of the pre-pit detection circuit 9 are disclosed in Japanese Patent Kokai No. 2000-311344, assigned to the assignee of the present application. The disclosure of Japanese Patent Kokai No. 2000-311344 is incorporated herein by reference.

The second synthesis signal is transmitted to a low pass filter 7 from the second synthesizing circuit 4, and becomes a track cross signal TCS. The second synthesis signal is also transmitted to an equalizer 8 and becomes a high frequency signal (RF signal) representing recorded information of the

optical disc.

The level adjusting circuit 2 performs the signal level adjustment such that the signal levels of three of the four signals A to D are adjusted to become equal to the signal level of the remaining one signal.

Figure 2 illustrates an example of the level adjusting circuit 2.

In this drawing, the signal A is directly supplied to the first and second synthesizing circuits 3 and 4 via a signal line 10. The signal A is also supplied to a level detection circuit 11. The level detection circuit 11 produces a level detection signal representing the signal level of the signal A. The signal B is amplified by a variable gain amplifier (VGA) 12 and introduced to the first and second synthesizing circuits 3 and 4. The amplified signal B is also introduced to a second level detection circuit 13. Like the first level detection circuit 11, the second level detection circuit 13 produces a level detection signal representing the signal level of the amplified signal B. The level detection signal is then introduced to one input of a comparator 14. The first level detection signal from the first level detection circuit 11 is introduced to the other input of the comparator 14. The comparator 14 creates a comparison signal having a level which represents a difference between the two input signals. The comparison signal is fed back to a control terminal of the VGA 12. The comparison signal is therefore a control signal.

The signal C is amplified by a second VGA 15 and supplied

to the first and second synthesizing circuits 3 and 4. The amplified signal C is also supplied to a third level detection circuit 16. The third level detection circuit 16 creates a third level detection signal representing the signal level of the amplified signal C. The third level detection signal is supplied to one input of a second comparator 17. The first level detection signal issued from the first level detection circuit 11 is supplied to the other input of the second comparator 17. The second comparator 17 produces a second comparison signal having a level that represents a difference between the two input signals, and returns the second comparison signal to a control terminal of the second VGA 15 as a control signal.

The signal D is amplified by a third VGA 18 and supplied to the first and second synthesizing circuits 3 and 4. The amplified signal D is also supplied to a fourth level detection circuit 19. The fourth level detection circuit 19 creates a fourth level detection signal representing the signal level of the amplified signal D. The fourth level detection signal is supplied to one input of a third comparator 20. The first level detection signal issued from the first level detection circuit 11 is supplied to the other input of the third comparator 20. The third comparator 20 produces a third comparison signal having a level that represents a difference between the two input signals, and returns the third comparison signal to a control terminal of the third VGA 18 as a control signal.

The three VGAs 12, 15 and 18 of the level adjusting circuit 2 therefore adjust (amplify) the signals B, C and D such that

each of the signal levels of the signals B, C and D becomes equal to the signal level of the signal A before the signals B, C and D are supplied to the first and second synthesizing circuits 3 and 4. The signal level of the signal A is not adjusted.

Since the signals A, B, C and D are adjusted as a whole to have the same level prior to introduction into the first and second synthesizing circuits 3 and 4, appropriate signal synthesis can be expected. Further, since the structure of the level adjusting circuit 2 is simpler than the prior art, the level adjusting circuit 2 can contribute to a reduction of the manufacturing cost of the signal synthesizing apparatus.

The term "signal level" of the signal A (or B or C or D) in this specification means a magnitude of the signal. The signal level may be a peak level difference of the signal, a peak level of the signal, an effective value of the signal, or an average value of the signals.

Referring to Figure 3, illustrated is an example of the level detection circuit 11 (or 13 or 16 or 19) when the peak level is used as the signal level. The level detection circuit 11 includes a high pass filter 30 which allows only a high frequency portion of the signal introduced to an input IN to pass therethrough, and a peak hold circuit 31 which maintains the peak of the signal issued from the high pass filter 30 and outputs the signal from an output OUT.

Referring to Figure 4, illustrated is another example of the level detection circuit 11 (or 13 or 16 or 19) when the peak level difference is used as the signal level. The level

detection circuit includes a high pass filter 32 which allows only a high frequency portion of the signal introduced to an input IN to pass therethrough, and a pair of peak hold circuits 33 and 34. One of the peak hold circuits 33 maintains the upper peak of the output signal of the high pass filter 32 and the other peak hold circuit 34 maintains the lower peak of the output signal of the high pass filter 32. The signals resulting from the upper and lower peak hold circuits 33 and 34 are introduced to a subtraction circuit 35. The subtraction circuit 35 outputs the peak level difference (i.e., difference between the upper and lower peaks) to an output OUT.

As understood from the foregoing, a plurality of beam segments A to D received at the light receiving unit 1 undergo the level adjustment without using a separately or specially determined reference value. Indeed, the reference value used in the signal synthesizing apparatus of the illustrated embodiment is the signal level of the signal A (light A), which is received at the light receiving unit 1.

Although the signal level of the light A is utilized as the reference value in this particular embodiment, the signal level of another light such as signal B, C or D may be used. Alternatively, an average value of two or more of the signals A to D may be utilized as the reference value. The reference value which varies with (i.e., which is determined from) at least one of the signals A to D can be used as the reference value.

It should be noted that the number of the light receiving

planes of the light receiving unit 1 is not limited to four, and the number of the signals to be received by the light receiving planes is not limited to four.

This application is based on a Japanese patent application No. 2001-33485, and the entire disclosure thereof is incorporated herein by reference.

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